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LIQUID CRYSTAL PANEL AND ITS MANUFACTURING METHOD

[Abstract]

PROBLEM TO BE SOLVED: To solve the problem, in a liquid crystal panel wherein a cell gap is supported by the protrusions formed on a substrate, the ease of generation of a low-temperature bubble and the strength to the pushing pressure of the panel depend on the sizes, shapes and the constitution of the underground of the protrusions and the optimal density of the protrusions is difficult to be found.

SOLUTION: It is effective that the density of the protrusions is controlled by the ratio of the sum total area of the protrusions coming, in contact with a color filter substrate to the display region area and the ratio of the sum total

area of the upper base of the protrusions which come into contact with the counter substrate to the display region area.

[Claim(s)]

[Claim 1] A liquid crystal panel comprising a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate being provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas of the projections which are contacted with the color filter substrate is 0.0016 or more times greater than surface areas of regions in which the color filter substrate is contacted with the liquid crystal material.

[Claim 2] A liquid crystal panel comprising a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate being provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas of the projections which are contacted with the opposite substrate is 0.0015 and less times smaller than surface areas of

regions in which the opposite substrate is contacted with the liquid crystal material.

[Claim 3] A liquid crystal panel comprising a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate being provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas of the projections which are contacted with the color filter substrate is 0.0016 or more times greater than surface areas of regions in which the color filter substrate is contacted with the liquid crystal material, and a sum of surface areas of the projections which are contacted with the opposite substrate is 0.0015 and less times smaller than surface areas of regions in which the opposite substrate is contacted with the liquid crystal material.

[Claim 4] A liquid crystal panel comprising a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate

being provided with a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas that the projections are contacted with the color filter substrate is 0.005 or more times greater than surface areas of regions that the color filter substrate is contacted with the liquid crystal material.

[Claim 5] A liquid crystal panel comprising a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate being provided with a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas that the projections are contacted with the opposite substrate is 0.003 and less times smaller than surface areas of regions that the opposite substrate is contacted with the liquid crystal material.

[Claim 6] A liquid crystal panel comprising a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed

to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate being provided with a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, characterized in that:

a sum of surface areas that the projections are contacted with the color filter substrate is 0.005 or more times greater than surface areas of regions that the color filter substrate is contacted with the liquid crystal material, and a sum of surface areas that the projections are contacted with the opposite substrate is 0.003 and less times smaller than surface areas of regions that the opposite substrate is contacted with the liquid crystal material.

[Claim 7] A method of manufacturing a liquid crystal panel, wherein a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, characterized in that:

a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with one of the substrates and surface areas of a region in which the substrate is contacted with the liquid

crystal material is above a desired value.

[Claim 8] A method of manufacturing a liquid crystal panel, wherein a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, characterized in that:

a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with the other substrate on which the projections are not formed and surface areas of a region in which the other substrate is contacted with the liquid crystal material is below a desired value.

[Claim 9] A method of manufacturing a liquid crystal panel, wherein a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, characterized in that:

a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with one of the substrates and surface areas of a region in which the substrate is contacted with the liquid

crystal material is above a desired value, and also a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with the other substrate on which the projections are not formed and surface areas of a region in which the other substrate is contacted with the liquid crystal material is below a desired value.

[Claim 10] A method according to any of claims 7 to 9, wherein one of the substrates, on which the plurality of projections are formed is the color filter substrate.

[Title of the Invention]

LIQUID CRYSTAL PANEL AND MANUFACTURING MEHTOD THEREOF

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a liquid crystal panel with projections for keeping a cell gap and a manufaturing method thereof.

[Description of the Prior Art]

FIG. 5 shows a conventional liquid crystal panel.

A liquid crystal panel is constructed by bonding two substrates, i.e., a color filter substrate 11 and an opposite substrate 12. Spacers are also provided between the two substrates so as to uniformly keep a gap therebetween.

As the spacers, spheral beads 51 formed of divinylbenzene-based or benzoguanamine-based resin, or silicon oxide-based inorganic spheral beads 51 are scattered on either side of the color filter substrate 11 and the opposite substrate 12, and the two substrates are then bonded.

This beads-scattering way is generally applied to most assembly

processes of the liquid crystal panel due to its convenience.

Recently, in accordance with the requirements relating to a progression in display quality of the liquid display panel, the following improvements are requested: (1) leakage of light through the scattered beads 51 and its peripheral region, or randomicity of the display quality or deterioration of contrast characteristics because of the light leakage by cohesion of the beads upon scattering, (2) progress in uniformity of the cell gap, (3) deterioration in the uniformity of the cell gap, or scratch on a surface of an alignment layer 3 because of movement of the bead particles 51 when vibrating the liquid crystal panel, etc.

In order to solve the problems, recently, there is proposed a method using photolithographic technology, etc., in which projections made of resin are formed as the spacers for keeping the cell gap on the color filter substrate so as to be disposed at regular intervals and also have the same height. Therefore, the bead-scattering operation is omitted in the method, (i.e., the method has a beadless construction). Furthermore, such method is already applied to some products.

[Problem(s) to be Solved by the Invention]

However, since the projection 52 formed on the color filter substrate

typically has a large amount of plastic deformation and a small amount of elastic deformation in comparison with the beads 51 formed of resin, there is a problem that a margin of choice for a design of projection formation density is narrowed.

In case that a liquid crystal panel having a large projection formation density is exposed to a low temperature of about -30°C, there is a problem that the amount of elastic deformation of the liquid crystal panel can not be match with a thermal shrink of liquid crystal material, thereby generating vacuum bubbles.

Meanwhile, in case of a liquid crystal panel having a small projection formation density, that is another problem that, since the projections are apt to be stuck in a resin layer such as a color filter layer, a light shielding layer, etc., which functions as a base portion of the projections, gap non-uniformity is occurred by non-uniform pressure in a manufacturing process, or unexpected load (pressure) upon using the panel, thereby lowering a strength of the panel.

As shown in FIGs. 2a and 2b, the projection 52 has a circular cone shape or a polypyramid shape of which a peak portion is cut away. Each surface area of an upper surface 53 and a lower surface 54 of the projection

52, and a ratio of the two surface areas may be variously formed in accordance with the resion material to be used or design conditions. Depending on the surface area or the shape of the projection and the construction of the resin layer, the bubble generation at a low temperature or the lowering of the panel strength is differently occurred. In the past, the design of projection formation density was determined by the number of projections, but designing in this way was not a sufficient and effective solution.

An object of the present invention is to obtain an effective solution for designing the projection formation density so as to restrain the bubble generation at a lower temperature, and an effective solution for for designing the projection formation density so as to restrain the occurrence of the gap non-uniformity due to the non-uniform pressure in a manufacturing process, or the unexpected load (pressure) upon using the panel.

[Means for Solving the Problem]

In order to solve the problems, a method of manufacturing a liquid crystal panel according to the present invention controls surface areas of the projections which are respectively contacted with the color filter substrate and the opposite substrate.

Since the bubble generation problem is caused by deterioration of elastic deformation amount of the panel at a low temperature, it is important to control an upper surface area of the projection, which mainly supports the panel. On the other hand, since the lowering of panel strength is caused by sticking of the projections into the color filter layer, it is important to control surface areas of surfaces of the projections which is contacted with the color filter substrate.

In other words, if the projections formed on the color filter substrate are uniformly arranged in an indicated range (in which the substrate is contacted with the liquid crystal material) of the liquid crystal panel, as for the bubble generation, it is preferred that the projection density is designed, regardless of a shape of the projection, an upper surface area and a lower surface area, so that a ratio of a sum of upper surface areas in the indicated region and the surface area of the indicated region is below a desired value. Further, as for the lowering of the panel strength, it is preferred that the projection density is designed, regardless of a shape of the projection, an upper surface area and a lower surface area, so that a ratio of a sum of lower surface areas in the indicated region and the surface area of the indicated region is above a desired value.

For example, assuming that the surface area of the indicated region is S, the upper surface area and the lower surface area of the projection are s-upper and s-lower, respectively, and the projection density is D (EA/surface area of the indicated region), if the bubble generation can be resctricted within an extent that the ratio of the sum (= S_1) of upper surface areas of the projections and the surface area S of the indicated region is α and less, and if the lowering of the panel strength can be also resctricted within an extent that the ratio of the sum (= S_2) of lower surface areas of ther projections and the surface area S of the indicated region is β or more, the following equations can be established:

$S_1/S \leq \alpha$ and $S_2/S \geq \beta$, further, since each of S_1 and S_2 can be also expressed as follows:

$S_1 = D \times S \times$ s-upper, $S_2 = D \times S \times$ s-lower, therefore, it is preferred that the projection density D is set to a follwing extent: β/s-lower $\leq D \leq \alpha$/s-upper.

Furthermore, in case that the projections are formed on the opposite substrate opposed to the color filter substrate, since the bubble generation and the lowering of the panel strength problems are depended upon the surface area (in this case, the upper surface area of the projection) which is contacted with the color filter substrate, it is preferred that the projection

density D is set to a follwing extent: β/s-upper ≤ D ≤ α/s-lower.

In addition, in the liquid crystal panel of the present invention, it is possible to set the ratio of the surface area of the indicated range and the surface areas of the projections, which are contacted with the color filter substrate and the opposite substrate, within a desired extent, thereby restricting the bubble generation and the lowering of the panel strength problems.

The value of this ratio is varied depending upon a layer construction of a region of the color filter substrate which is contacted with the projection. In case of the projections formed on the color filter substrate having the transparent electrode, as shown in FIG. 3, it is preferred that the sum of the surface areas of the projections which are color filter substrate 11 is 0.0016 or more times the surface area of the indicated region, and the sum of the surface areas of the projections which are opposite substrate 11 is 0.0015 and less times the surface area of the indicated region.

Further, in case of the projections formed on the color filter substrate 11 for IPS mode, in which the transparent electrode is not formed, as shown in FIG. 4, it is preferred that the sum of the surface areas of the projections which are color filter substrate 11 is 0.005 or more times the surface area of

the indicated region, and the sum of the surface areas of the projections which are opposite substrate 11 is 0.003 and less times the surface area of the indicated region.

[Embodiment of the Invention]

A liquid crystal panel described in claim 1 comprises a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate is provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface areas of the projections which are contacted with the color filter substrate is 0.0016 or more times surface areas of regions in which the color filter substrate is contacted with the liquid crystal material.

A liquid crystal panel described in claim 2 comprises a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate is provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface

areas of the projections which are contacted with the opposite substrate is 0.0015 and less times surface areas of regions in which the opposite substrate is contacted with the liquid crystal material.

A liquid crystal panel described in claim 3 comprises a color filter substrate, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate is provided with a transparent electrode and a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface areas of the projections which are contacted with the color filter substrate is 0.0016 or more times surface areas of regions in which the color filter substrate is contacted with the liquid crystal material, and a sum of surface areas of the projections which are contacted with the opposite substrate is 0.0015 and less times surface areas of regions in which the opposite substrate is contacted with the liquid crystal material.

A liquid crystal panel described in claim 1 comprises a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the

color filter substrate is provided with a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface areas that the projections are contacted with the color filter substrate is 0.005 or more times surface areas of regions that the color filter substrate is contacted with the liquid crystal material.

A liquid crystal panel described in claim 5 comprises a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate is provided with a plurality of projections for uniformly keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface areas that the projections are contacted with the opposite substrate is 0.003 and less times surface areas of regions that the opposite substrate is contacted with the liquid crystal material.

A liquid crystal panel described in claim 6 comprises a color filter substrate on which a transparent electrode is not formed, an opposite substrate opposed to the color filter substrate, and a liquid crystal material interposed between the color filter substrate and the opposite substrate, the color filter substrate is provided with a plurality of projections for uniformly keeping

keeping a gap between the color filter substrate and the opposite substrate, and a sum of surface areas that the projections are contacted with the color filter substrate is 0.005 or more times surface areas of regions that the color filter substrate is contacted with the liquid crystal material, and a sum of surface areas that the projections are contacted with the opposite substrate is 0.003 and less times surface areas of regions that the opposite substrate is contacted with the liquid crystal material.

In a method of manufacturing a liquid crystal panel described in claim 7, a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, and a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with one of the substrates and surface areas of a region in which the substrate is contacted with the liquid crystal material is above a desired value.

In a method of manufacturing a liquid crystal panel described in claim 8, a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded

with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, and a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with the other substrate on which the projections are not formed and surface areas of a region in which the other substrate is contacted with the liquid crystal material is below a desired value.

In a method of manufacturing a liquid crystal panel described in claim 9, a plurality of projections are formed on one of a pair of substrates so as to keep a gap between the pair of substrates, the pair of substrates are bonded with the projections being interposed therebetween, and a liquid crystal material is interposed between the pair of substrates, and a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with one of the substrates and surface areas of a region in which the substrate is contacted with the liquid crystal material is above a desired value, and also a density of the projections is designed so that a ratio of a sum of surface areas of the projections which are contacted with the other substrate on which the projections are not formed and surface areas of a region in which the other substrate is contacted with the liquid crystal material is below a desired value.

In a method of manufacturing a liquid crystal panel described in claim 10, one of the substrates, on which the plurality of projections are formed is the color filter substrate.

The present invention will now be described in further detail by examples.

(First embodiment)

By way of assembling a 13.3-inch XGA-TFT liquid crystal panel, a relationship between the bubble generation and the panel strength was investigated with respact to a density of projections 52.

First, fourteen sheets of color filter substrates for a 13.3-inch XGATN-liquid crystal panel were prepared for the investigation. As shown in FIG. 3, a transparent electrode is formed on a surface of the color filter substrate.

On each of seven sheets a1, b1, c1, d1, e1, f1, g1 out of the fourteen sheets of color filter substrates 11, acryl-based resistor (as a material E of the projection) is coated by a spin coater so that a coated film has a thickness of 4.7μm. The coated substrates are pre-baked, exposed through a mask having a desired pattern to ultraviolet rays, developed and then post-baked, thereby forming the projection 52.

At this time, as shown in FIG. 2a, the projection 52 has a circular cone

shape of which a peak portion is cut away. Each surface area of an upper surface 53 and a lower surface 54 of the projection 52 (hereinafter, respectivelh called as "upper surface area" and "lower surface area") is shown in table 1. The upper surface is defined as a surface area 55 of a portion, which is located at approximately 90 percent of an entire height of the projection 52, in consideration of the plastic deformation and the elastic deformation of the projection 52 after forming of the panel.

Table 1

Substrate No.	Material of projection	Diameter of upper surface (μm)	Diameter of lower surface (μm)	Upper surface (μm^2)	Lower surface (μm^2)
a1, b1, c1, d1, e1, f1, g1	E	10	21	78.5	346.2
a2, b2, c,2, d2, e2, f2, g2	F	10	15	78.5	176.6

Further, seven kinds of pattern masks are used in the exposure process so as to differently form the projection density. Therefore, each of the seven sheets of the color filter substrates has a different projection density by using each of the different pattern masks. A relationship between the color filter substrates 11 and the projection density is shown in table 2.

Table 2

Substrate No.	Material of	Projection	Projection	Projection

	projection	density A (the number/mm^2)	density B (sum of upper surface areas /unit surface area)	density C (sum of lower surface areas /unit surface area)
a1	E	4.8	0.000377	0.001662
b1	E	7.2	0.000565	0.002492
c1	E	9.6	0.000754	0.003323
d1	E	14.4	0.001130	0.004985
e1	E	19.2	0.001507	0.006647
f1	E	28..8	0.002260	0.009970
g1	E	43.2	0.003393	0.014958
a2	F	4.8	0.000377	0.000848
b2	F	7.2	0.000565	0.001271
c2	F	9.6	0.000754	0.001695
d2	F	14.4	0.001130	0.002543
e2	F	19.2	0.001507	0.003391
f2	F	28.8	0.002260	0.005086
g2	F	443.2	0.003393	0.007632

On the rest of seven sheets of color filter substrates a2, b2, c2, d2, e2, f2, g2, other acryl-based resistor (as a material F of the projection) is coated by the spin coater so that a coated film has a thickness of 4.7μm. The coated substrates are pre-baked, exposed through a mask having a desired pattern to ultraviolet rays, developed and then post-baked, thereby forming the projection 52.

At this time, if the projection formed of the material F is compared with that formed of the material E, the projection formed of the material F has the same shape, i.e., the circular cone shape of which a peak portion is cut away, as shown in FIG. 2a, and the same definition and value of the upper surface area. However, the projection formed of the material F has a different value of

the lower surface area. Each of the upper and lower surface areas is shown in Table 1.

Further, like the material E, other seven kinds of pattern masks are used in the exposure process so as to differently form the projection density. Therefore, each of the seven sheets of the color filter substrates has a different projection density by using each of the different pattern masks. A relationship between the color filter substrates 11 and the projection density is also shown in table 2.

In the table 2, there are shown the total number of projections with respect to the surface area of a region (indicated region) that the liquid crystal material is contacted with the substrate, i.e., the number of projections per the surface area of $1mm^2$ (projection density A), and the sum of the upper surface areas per unit surface area of the indicated region, i.e., the ratio of the sum of the upper surface areas of the projections and the surface area of the indicated region (projection density B), and the ratio of the sum of the lower surface areas of the projections and the surface area of the indicated region (projection density C). In the ratio of the sum of the upper surface areas of the projections and the surface area of the indicated region (projection density B), for example, in case of the color filter substrate

a1, since the projections which respectively have an upper surface area of 78. 5μm^2 are formed in a density of 4.8 EA / 1mm^2 and 1 μm^2 is 1 x 10^{-6}mm^2, the upper surface area can be calculated as follows: 78.5 x 4.8 x 10^{-6} =0.0003768.

Then, the fourteen sheets of color filter substrates a1 to g1 and a2 to g2 and prepared fourteen sheets of opposite substrates 12 are treated by, in turn, a substrate cleaning process, an alignment layer printing process, a hardening process of the alignment layer, a rubbing process in a desired direction, and then another cleaning process after the rubbing process. At this time, the alignment layer is formed of a polyimide-based material and has a thickness of 50 ~ 80nm.

A seal printing process is performed on the color filter substrate 11, and a conductive paint is coated on the opposite substrate 12. At this time, the seal material contains glass fibers of 2.0 %, having a diameter of 5.2 μm.

Then, the fourteen sets of color filter substrates 11 and the opposite substrates 12 are bonded. After the seal material is hardened, desired processes such a glass cutting process, a liquid crystal injecting process, a sealing process, etc., are performed. Therefore, as shown in FIG. 1, fourteen sheets of liquid crystal panels 10 (hereinafter, respectively called as "a1 to g1, a2 to g2" are fabricated.

With respect to the fabricated fourteen sheets of liquid crystal panels 10, first, an examination of the bubble generation at a low temperature is performed.

After exposing all of the fourteen sheets of liquid crystal panels 10 to a low temperature of -30°C for 6 hours, it is investigated whether bubbles are generated. Further, on the panel in which the bubbles are not generated, an iron ball 9 of 10g is dropped down from a height of 30cm. Then, it is also investigated whether the bubbles are generated. The results thereof are shown in table 3.

Table 3

Panel No.	Bubble generation state	Gap non-uniformity generation state		
		$1kgf/cm^2$	$3kgf/cm^2$	$5kgf/cm^2$
a1	O	O	Δ	X
b1	O	O	O	X
c1	O	O	O	Δ
d1	O	O	O	O
e1	Δ	O	O	O
f1	X	O	O	O
g1	X	O	O	O
a2	O	Δ	X	X
b2	O	O	X	X
c2	O	O	Δ	X
d2	O	O	O	X
e2	Δ	O	O	Δ
f2	X	O	O	O
g2	X	O	O	O

In the table 3, a symbol X indicates a bubble generation state after the panel

is exposed to the low temperature, Δ indicates a bubble generation state after the an impact is applied to the panel by the iron ball 9, and O is a state that the bubbles are not generated in both cases.

According to the bubble generation state shown in table 3, it appears that the more the projection density is increased, the more the bubble generation state is deteriorated. However, regardless the difference between the materials E and F, if the ratio of the sum of the upper surface areas of the projections and the surface area of the indicated region (projection density B) is 0.0015 or more, it is easy to generate the bubbles.

That is, the bubble generation state is determined by the ratio of the sum of the upper surface areas and the surface area of the indicated region.

Continuously, with respect to the liquid crystal panels 10, an examination of panel strength is performed. As shown in FIG. 7, in a status that a spring balance 8 is interposed between the two liquid crystal panels, three different loads, i.e., 98kPa (1kgf/cm^2), 294kPa (3kgf/cm^2), 490kPa (5kgf/cm^2) are respectively applied to the liquid crystal panels. Then, a change state of cell gap is visually observed. Like the bubble generation state, the result is shown in table 3.

Furthermore, in the table 3, the symbols O, Δ and X indicate cell gap

non-uniformity state of a portion of the liquid crystal panels, in which each of the different loads is applied. The symbol O shows the cell gap non-uniformity of 0.04 μm and less, the symbol Δ shows the cell gap non-uniformity of 0.04 μm through 0.08 μm and the symbol X the cell gap non-uniformity of 0.08 μm or more.

According to the cell gap non-uniformity state shown in table 3, it appears that the more the projection density is decreased, the more the cell gap non-uniformity state is deteriorated. However, regardless the difference between the materials E and F, it is easy to occure the cell gap non-uniformity corresponding to the ratio of the sum of the lower surface areas of the projections and the surface area of the indicated region (projection density C).

Meanwhile, since it is not general status that the load applied to the liquid crystal panel during or after the panel assembly process is 294kPa ($3kgf/cm^2$) or more, it can assume that the liquid crystal panel having a level of symbol Δ under the load of 294kPa ($3kgf/cm^2$) is excellent. On the basis of this fact, if the ratio of the sum of the lower surface areas of the projections and the surface area of the indicated region (projection density C) is 0.0016 or more, as for the panel strength matter, the panel can be regarded as an

excellent product.

(Second embodiment)

In the sencond embodiment, the same examination as that in the first embodiment was performed with other color filter substates for an IPS-liquid crystal panel, in which the transparent electrode was not formed.

First, fourteen sheets of color filter substrates for a 13.3-inch XGA or IPS-liquid crystal panel were prepared for the examination. As shown in FIG. 4, these color filter substates are for the IPS-liquid crystal panel, and the transparent electrode is not formed on a surface of the color filter substrate.

Like in the first embodiment, on each of seven sheets a3, b3, c3, d3, e3, f3, g3 out of the fourteen sheets of color filter substrates 11, acryl-based resistor (as a material E of the projection) is coated by a spin coater so that a coated film has a thickness of 4.7μm. And on the rest of seven sheets of color filter substrates a4, b4, c4, d4, e4, f4, g4, other acryl-based resistor (as a material F of the projection) is also coated by the spin coater so that a coated film has a thickness of 4.7μm. The coated substrates are pre-baked, exposed through a mask having a desired pattern to ultraviolet rays, developed and then post-baked, thereby forming the projection 52.

At this time, except a fact that a height of the projction is lowered, the

projection 52 has a circular cone shape of which a peak portion is cut away, as shown in FIG. 2a. Further, as for the lower surface area of the projection, it is the same as that in the first embodiment as shown in table 4.

Table 4

Substrate No.	Material of projection	Diameter of upper surface (μm)	Diameter of lower surface (μm)	Upper surface (μm^2)	Lower surface (μm^2)
a3, b3, c3, d3, e3, f3, g3	E	10	21	78.5	346.2
a4, b4, c4, d4, e4, f4, g4	F	10	15	78.5	176.6

Further, as for the projection density, each of the panels is also fabricated, like in the first embodiment, using the seven different pattern masks, as shown in table 5.

Table 5

Substrate No.	Material of projection	Projection density A (the number/mm^2)	Projection density B (sum of upper surface areas /unit surface area)	Projection density C (sum of lower surface areas /unit surface area)
a3	E	4.8	0.000377	0.001662
b3	E	7.2	0.000565	0.002492
c3	E	9.6	0.000754	0.003323
d3	E	14.4	0.001130	0.004985
e3	E	19.2	0.001507	0.006647
f3	E	28..8	0.002260	0.009970
g3	E	43.2	0.003393	0.014958
a4	F	4.8	0.000377	0.000848
b4	F	7.2	0.000565	0.001271
c4	F	9.6	0.000754	0.001695

d4	F	14.4	0.001130	0.002543
e4	F	19.2	0.001507	0.003391
f4	F	28.8	0.002260	0.005086
g4	F	443.2	0.003393	0.007632

Then, the fourteen sheets of color filter substrates a3 to g3 and a4 to g4 and prepared fourteen sheets of opposite substrates 12 are treated by, in turn, a substrate cleaning process, an alignment layer printing process, a hardening process of the alignment layer, a rubbing process in a desired direction, and then another cleaning process after the rubbing process. At this time, the alignment layer is formed of a polyimide-based material and has a thickness of 50 ~ 80nm.

A seal printing process is performed on the color filter substrate 11, and a conductive paint is coated on the opposite substrate 12. At this time, the seal material contains glass fibers of 2.0 %, having a diameter of 5.2 μm.

Then, the fourteen sets of color filter substrates 11 and the opposite substrates 12 are bonded. After the seal material is hardened, desired processes such a glass cutting process, a liquid crystal injecting process, a sealing process, etc., are performed. Therefore, fourteen sheets of liquid crystal panels 10 (hereinafter, respectively called as "a3 to g3, a4 to g4" are fabricated.

With respect to the fabricated fourteen sheets of liquid crystal panels

10, like in the first embodiment, examinations of the bubble generation at a low temperature and the panel strength are performed. The results are shown in table 6.

Table 6

Panel No.	Bubble generation state	Gap non-uniformity generation state		
		$1kgf/cm^2$	$3kgf/cm^2$	$5kgf/cm^2$
a3	O	Δ	X	X
b3	O	Δ	X	X
c3	O	O	X	X
d3	O	O	Δ	X
e3	O	O	O	X
f3	O	O	O	O
g3	X	O	O	O
a4	O	X	X	X
b4	O	Δ	X	X
c4	O	Δ	X	X
d4	O	Δ	X	X
e4	O	O	X	X
f4	O	O	O	X
g4	X	O	O	Δ

According to the bubble generation state shown in table 6, like in the first embodiment, it appears that the more the projection density is increased, the more the bubble generation state is deteriorated. However, regardless the difference between the materials E and F, the bubble generation state is determined by the ratio of the sum of the upper surface areas and the surface area of the indicated region.

In case of the color filter substrate in which the transparent electrode

is not formed, if the ratio of the sum of the upper surface areas of the projections and the surface area of the indicated region (projection density B) is 0.003 or more, it is easy to generate the bubbles.

Moreover, according to the cell gap non-uniformity state, like in the first embodiment, it appears that the more the projection density is decreased, the more the cell gap non-uniformity state is deteriorated. However, regardless the difference between the materials E and F, it is easy to occure the cell gap non-uniformity corresponding to the ratio of the sum of the lower surface areas of the projections and the surface area of the indicated region (projection density C).

In case of the color filter substrate in which the transparent electrode is not formed, if the ratio of the sum of the lower surface areas of the projections and the surface area of the indicated region (projection density C) is 0.005 or more, as for the panel strength matter, the panel can be regarded as an excellent product.

It seems that the difference between the preferable values of the projection density, in accordance with whether the transparent electrode is existed or not, is caused by a fact that a strength of the transparent electrode is high. Therefore, it appers that the stuck depth (plastic deformation amount

and elastic deformation amount) of the projection formed on the transparent electrode is descreased.

[Effect of the Invention]

According to the liquid crystal panel of the present invention, it is possible to restrick the bubble generation and also to obtain a sufficient strength of the panel. Further, according to the method of manufacturing the the liquid crystal panel of the present invention, the bubble generation is prevented, and the liquid crystal panel having the sufficient strength can be stably manufactured.

[Description of Drawings]

FIG. 1 is a schematic view of a liquid crysta panel fabricated by a manufacturing method according to an embodiment of the present inventnion.

FIG. 2 is a schematic view of a projection.

FIG. 3 is a schematic view of a color filter substrate in which the projection is formed on a transparent electrode.

FIG. 4 is a schematic view of a color filter substrate in which the transparent electrode is not formed.

FIG. 5 is a schematic view of a liquid crystal panel in which a cell gap is maintained by scattered beads.

FIG. 6 is a view of an example of an examination for investigating whether the bubble is generated by an impact.

FIG. 7 is a view of an example of an examination for measuring a panel strength.

[Meaning of numerical symbols in the drawings]

3 : alignment layer

4 : transparent electrode

6 : array wire

7 : liquid crystal layer

8 : spring balance

9 : iron ball

10 : liquid crystal panel

11 : color filter substrate

12 : opposite substrate

21 : black matrix (light shielding layer)

22 : color filter layer

51 : bead

52 : projection

53 : upper surface of the projection

54 : lower surface of the projection

55 : section for defining the upper surface of the projection